Space Weather Technical Forecast

Issued on Friday, 29 April 2022 at 13:08 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1/G2 Minor/Moderate geomagnetic storm intervals possible in first half of forecast period. Gradually reducing likelihood of M-class flares (R1/R2 Radio Blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity rose to Moderate in the past 24 hours, with a solitary long-period M1.2 observed at 29/0730UTC. This feature appeared to emanate from the plage remnant of Ex-2996 in the northwestern quadrant. This was preceded by movement in a filament to the immediate southwest, visible in Learmonth H-alpha imagery, and was roughly coincident with a much more energetic filament lift off from the environs of Ex-2996 itself. This is now beginning to show on STEREO A COR2 imagery and will be analysed as soon as triangulating imagery becomes available from Lasco. If two CMEs were indeed emitted, early imagery suggests the former is very likely to have been subsumed in the latter, with only one in evidence leaving the sun.

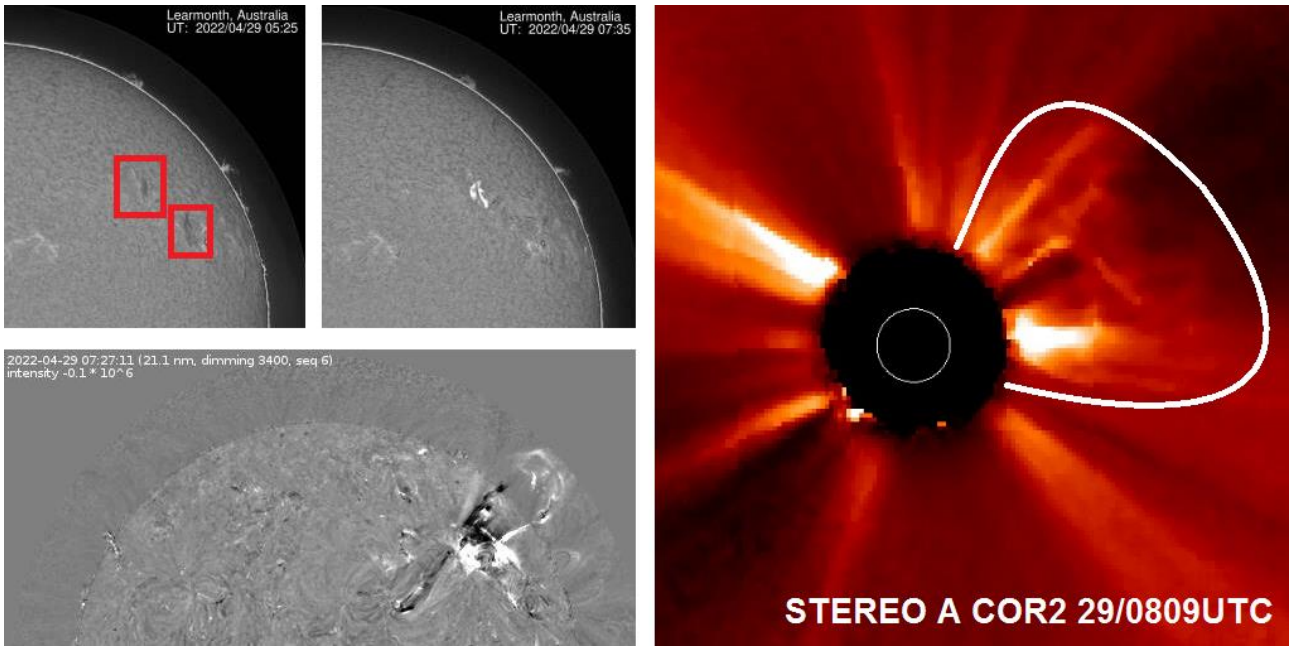

Figure 0: Imagery related to northwest quadrant activity during UTC morning of 29 April. Clockwise from top left: Learmonth H-alpha imagery showing boxed red filaments that later disappeared (centre top); STEREO A coronagraph of the ejecta; and AIA 211 time-integrated dimming of CME tied to M1.2 flare, processing courtesy of SIDC ROB.

There are currently up to eight sunspot regions on the visible disc, with these broadly falling into three main 'areas'. First amongst these is the aforementioned active northwestern quadrant in general, which contains AR2995, an Hhx/Alpha with a history of transient very minor peripheral pores; the trailer of AR2994; the now limb-occupying AR2993 - as well as Ex-2996's plage. The

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detail and trends in these groups is mostly very hard to discern, however the trailer of AR2994 appears to be at least Dai/Beta.

Secondly, the central portion of the sun contained two bipolar regions in the form of AR2997, a Bxo/Beta; and 2999, a Cho/Beta. Both are displaying very minor trailing spots at some distance from their leading groups, but were otherwise unremarkable. Finally, the southeastern quadrant was the preserve of up to four very minor groups, all unipolar or simple dipoles, again with no notable growth or flaring.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, has in retrospect been determined to be symptomatic of connection to coronal hole 78's high speed stream, with the phi angle accordingly negative throughout (towards the sun). This may have occurred as early as the UTC afternoon of Wednesday 27 April, likely narrowly preceded by a CIR.

The solar wind speed was Elevated in the past 24 hours, with the trace oscillating within 500-550km/s, while the solar wind density stayed within high single figures ppcc. The IMF showed a slight fall over the same period, peaking at 9nT, with the north-south component varying between +5 and -6nT. The net result of the above solar wind measures was Quiet to Active, with two provisional peaks of Kp 4- in the early hours UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV) was at Background levels throughout, despite the western solar hemisphere M-class flare.

The high energy electron flux (greater than 2MeV) has been at Normal Background to Moderate levels. The associated 24-hour fluence remained below the Active (1e8 integrated pfu) level, with a slight rising trend and an 29/0000UTC observation of 7.17e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Slight Chance of further M-class activity, although this is expected to wane during the second half of the forecast period, perhaps significantly so by the very end of the four days as recent active regions successively depart for the far side.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast carries relatively high uncertainty. Current modelling suggests the potential arrival of a CME which left the Sun around 27/1450UTC in the next 18 hours or so. A CME from 28 April may catch up with this first CME to complicate its influence. There is otherwise the one unassessed M1.2 flare and filament CME, with updates to follow. Provisionally, this final feature appears to have originated little too far west and north on the disc to be a significant risk to Earth.

Contrary to earlier guidance, Earth is now thought very likely to be seeing the influence from coronal hole 78, with this likely to have already peaked in terms of intensity, from here waning later in the UTC weekend. This is the only coronal hole to feature in the forecast.

All considered, there is a Chance of G1/Minor Storm (Kp 5) intervals on day one (Friday 29 April), should the impending CME(s) arrive ahead of forecast. During 30 April, geomagnetic activity is Likely to result in G1/Minor Storm (Kp 3-5), with a Chance of G2/Moderate Storm (Kp 6) intervals, easing back to increasingly Quiet conditions from Sunday 01 May and into the new working week in a (by this time) nominal solar wind environment.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) is most likely to remain at Background levels through the next four days, with the current slightly raised daily chance of breaching S1 falling with the passing of the most significant front-sided regions.

The high energy electron flux (greater than 2MeV) forecast carries relatively low confidence owing

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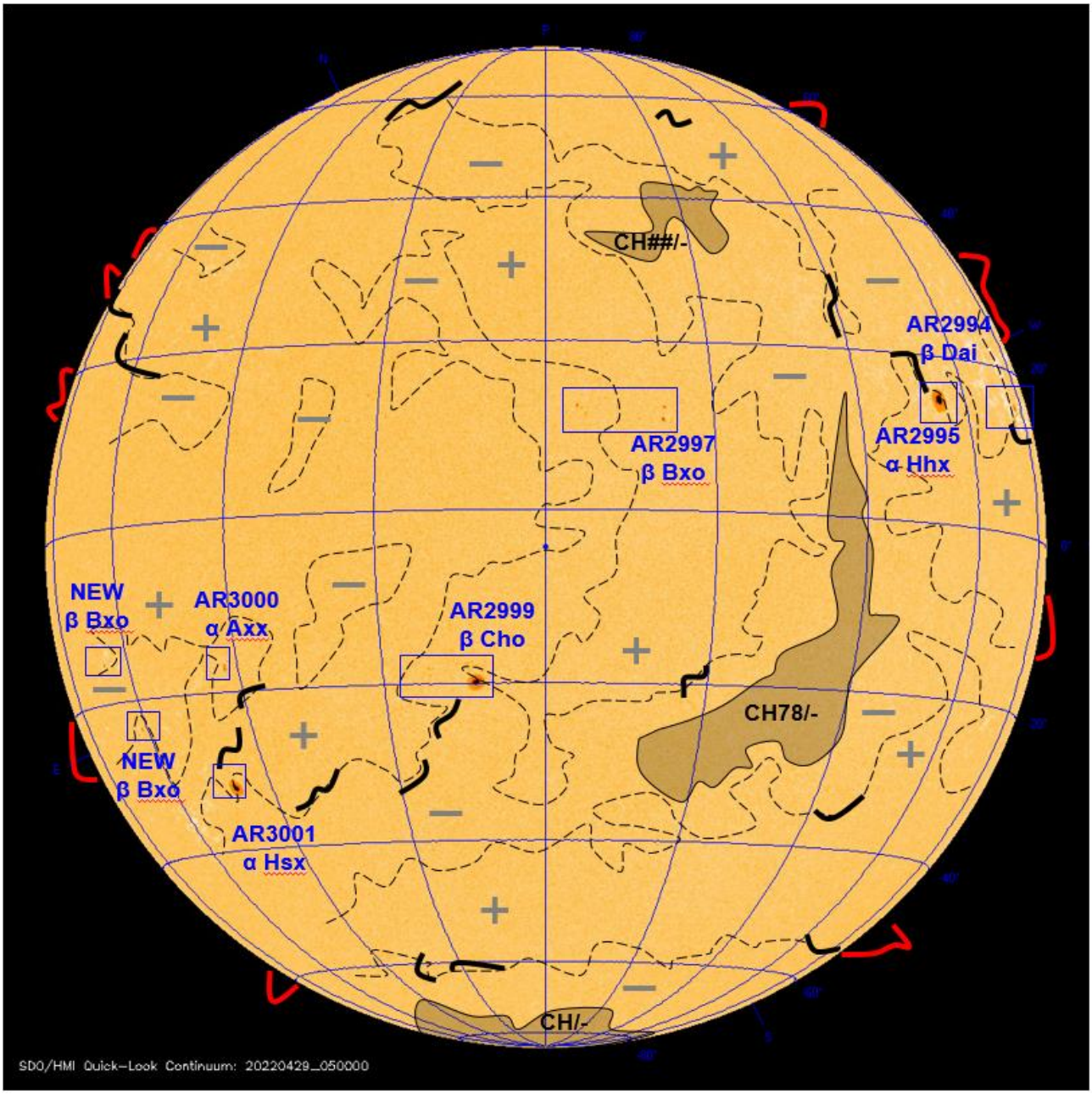
to the presence of CMEs in the forecast, however the current diurnal oscillation may increase initially, before perhaps paring back under any arising geomagnetic influence. Levels should stabilise later in the period, with a nominal solar wind environment arriving into the new working week UTC.

Figure 1. Solar Analysis Valid 29/0500UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic forecast carries relatively high uncertainty.

Current modelling suggests the potential arrival of a CME which left the Sun around 27/1450UTC in the next 18 hours or so. A CME from 28 April may catch up with this first CME to complicate its influence.

This CME originated form a long duration C7 flare in the northern hemisphere of the Sun, peaking around 27/1450UTC. It's positioning and lack of imagery has meant that several analyses have taken place, with below-average confidence in the detail. Evidence suggests that this CME may catch up with another earlier event released from a similar position, perhaps gathering material. Its initial velocity was around 800-900km/s but this will likely become 550-600km/s (chance of 650km/s) upon arrival at L1 and Earth. There is otherwise the one unassessed M1.2 flare and filament CME, with updates to follow. Provisionally, this final feature appears to have originated little too far west and north on the disc to be a significant risk to Earth.

Contrary to earlier guidance, Earth is now thought very likely to be seeing the influence from coronal hole 78, with this likely to have already peaked in terms of intensity, from here waning later in the UTC weekend. This is the only coronal hole to feature in the forecast.
All considered, there is a Chance of G1/Minor Storm (Kp 5) intervals on day one (Friday 29 April), should the impending CME(s) arrive ahead of forecast. During 30 April, geomagnetic activity is Likely to result in G1/Minor Storm (Kp 3-5), with a Chance of G2/Moderate Storm (Kp 6) intervals, easing back to increasingly Quiet conditions from Sunday 01 May and into the new working week in a (by this time) nominal solar wind environment.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	70	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/2138	Partial	C7 flare	NW quadrant	830km/s	30/0200UTC +/-6hrs	Possible glancing blow

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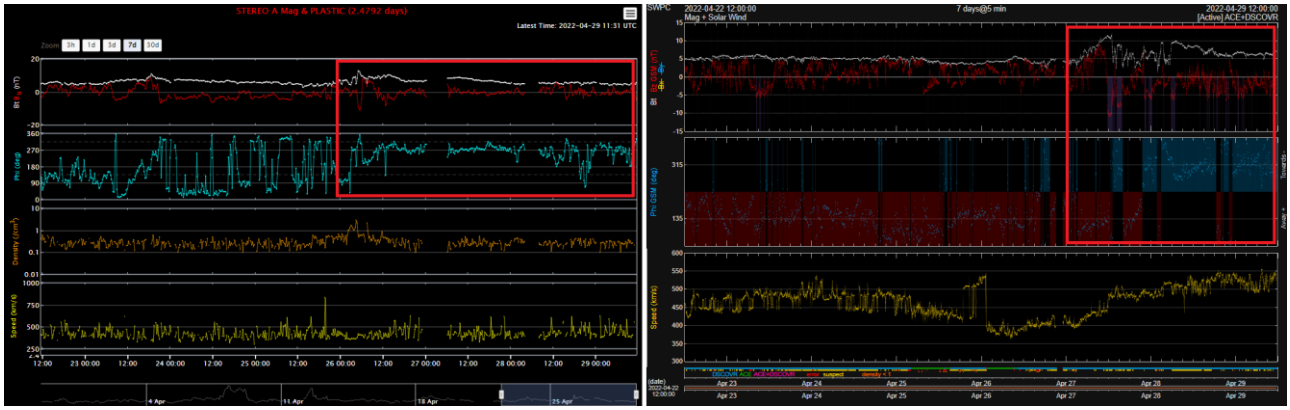
Figure 2: Selected 7-day STEREO A MAG and PLASTIC traces (left) and L1 (right), showing boxed in red the similarities in solar wind behaviour, now thought very likely to be CH78.



Radio Blackouts - X-Ray Flares:

The expected trend in X-ray flux in the period is downward, with the gradual rotation from view of the very active northwestern quadrant of the past fortnight. This includes sunspot region AR2993, which has already faded from view, shortly to be followed by AR2994 and then the plage remnant of Ex-2996 in turn, which again defied expectations in generating the largest X-ray flare of the period in the form of an M1.2 at 29/0730UTC. While the sun currently shows up to eight sunspot regions, many of these are small and stable, with measures such as Penticton 10.7cm flux and background X-rays at GOES16 already falling.

The far side is not without potential large regions however, with bright flux becoming visible at low solar latitude in STEREO A's EUVI 195 imagery. This may be the surviving cause of numerous unusually low latitude far-sided CMEs in the past two weeks. Should there be a region here this would begin to factor into consideration into the new working week UTC. In the longer term, there is a possible large region visible in soundings diametrically opposite Earth's viewpoint, with this feature due in around a week's time.

On balance, as stated the trend in flares should be down, with a daily Slight Chance of M-class flares falling, perhaps appreciably so at the very end of the current four days.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	20	10	10
Very Active	R3 to R5 X Class	No	5	5	1	1

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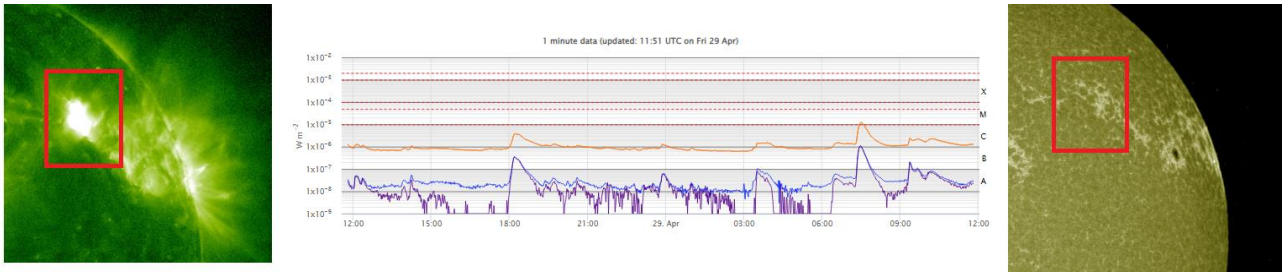
Figure 3: Left to right: AIA 094 imagery as a proxy for M1.2 X-ray flare observed from Ex-2996 at 29/0730UTC; GOES16 X-ray flux; AIA 1600, showing plage region from which the flare emanated.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as measured by GOES-16 at GEO is at background levels, and is most likely to remain so through the next four days.

Although the northwestern quadrant and the immediate far side is currently populated by large and complex regions with a history of M-flares and above, there has not been any tied proton enhancement - in fact since the very start of the current month. So, while there is a nominal very slightly raised risk of S1 and above going into the UTC weekend, this remains low, and should fall into the following working week.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	5	5	2	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) is expected to vary between Normal Background and Moderate levels at first. With the onset of coronal hole 78 now thought to already be in course, any upsurge in flux ought to occur in the very near-term, although with CMEs in the forecast due to arrive shortly after any increase, this may be too short-lived to cause 24-hour integrated fluence.

Confidence for the forecast period as a whole is low overall, as although the current solar wind speed is actually a fairly close fit for last rotation, any passing CMEs are likely to cause this deviate. The risk of Active fluence should rise through the period, as indicated in current MOSWOC REFM output albeit with large error bars, and in any case most likely falling a little below Active, even by day four in the ensuing nominal solar wind environment.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	20	40	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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